AMBIENT SULPHUR DIOXIDE, SULPHURIC ACID MIST, AND TOTAL SUSPENDED PARTICULATE LEVELS IN THE VICINITY OF RED RIVER BRICK AND TILE CO. LTD., LOCKPORT, MANITOBA
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ABSTRACT

At the request of the Air Pollution Control Section of Environmental Control Services, operators of the Mobile Monitoring Unit carried out a study to determine ambient ground level concentrations of sulphur dioxide, sulphuric acid mist and total suspended particulate in the environs of Red River Brick and Tile Co. Ltd., Lockport, Manitoba, during May 1984. Results from the study indicate that contaminant levels in the vicinity, primarily arising from plant emissions, could exceed the Manitoba Ambient Air Quality criteria under certain meteorological conditions.

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1. BACKGROUND

Red River Brick and Tile, a division of I-XL Industries Ltd. has operated a plant for the manufacture of extruded, burnt clay bricks in the vicinity of Lockport, Manitoba, since the early 1970's.

Plant process operations are divided into two major areas, clay grinding and brick manufacturing, with storage facilities provided for raw clay, and for finished brick products.

Unprocessed clay, obtained from Ste. Rose du Lac, Brokenhead and Morden areas of Manitoba, is first crushed into pieces two to three inches in diameter, and then fed into a rim discharge grinder to further reduce the size to less than one-half inch diameter. The finished product is passed through vibrating screens and stored in bins. The grinder has a rated maximum capacity of 50 tons per hour, but normal capacity is 30 tons per hour.

Brick ingredients are mixed in a pug mill, under vacuum, to a paste. The mixture, when proper consistency is achieved, is forced out by an extruder in the form of a continuous ribbon. Additives are applied to give surface textures to the wet bricks which are then cut to correct dimensions by fine wires. Sized bricks are piled on 10 foot square platform cars (4500 to 5000 bricks/car), and placed in a holding area for one to three days to begin the drying process. The cars are then routed through a drier, where the temperature is gradually increased to 150° Celsius (300° Fahrenheit) over a period to two days to complete the drying process before the bricks are fired.

Firing consists of six basic steps: evaporation of water, dehydration of bound water, oxidation, nitrification, flashing and cooling. The bricks spend two or more days travelling through the tunnel kiln, with temperatures at flashing points reaching as high as 1250°C (2300°F). Overall temperature, flashing points, length of time in the kiln and clay mixture used all influence the colour and strength of the final product.

Several areas of the brick manufacturing process may contribute significant quantities of emissions into the atmosphere. Air pollutants are typically of gaseous and particulate origin. They originate from the following sources in the plant:

(a) discharges from the rotary dryer exhaust;

(b) discharges from the kiln exhaust of particulate and gaseous emissioins from compounds burned out of the clay;

(c) re-entrainment of dust from stock piles of clay on the premises.

Sulphur dioxide will be emitted from certain types of clay when firing temperatures are high enough. Due to relatively high vapour content in the kiln exhaust, sulphur dioxide becomes readily hydrated, yielding acid mist upon cooling below the dew point.

Stack sampling surveys of emission levels from the Red River Brick and Tile plant have been performed. In 1975, particulate emission levels were found to be below the Clean Environment Commission emission limit of 0.05 grams/scm [1].

After construction of a 30 foot kiln exhaust stack in October 1979, further stack sampling was undertaken. In 1980, particulate concentrations (0.707 grams/scm) were found to be above the emission limit of 0.570 grams/scm, while sulphur dioxide emissions were measured as 2.331 grams/scm and 0.294 grams/scm respectively [2]. After repairs were undertaken, a second stack sampling survey of the kiln exhaust stack in 1981 established that the particulate emissions were in compliance with stipulated limits. Sulphur dioxide gas and sulphuric acid mist concentrations were determined to be 3.039 grams/scm and 0.560 grams/scm respectively [3]. At present no compliance limits are in existence for sulphur dioxide and sulphuric acid mist emissions.

At the request of the Air Pollution Control Section of Environmental Control Services, a study was undertaken, utilizing the Mobile Monitoring Unit downwind of the plant.

Sampling was performed during the selected days as meteorological conditions permitted and as access to affected areas allowed.

Specific objectives of this study were:

1. To determine ambient ground level concentrations of sulphur dioxide, sulphuric acid mist, and total suspended particulate in the vicinity of the plant.

2. To compare concentration levels to Manitoba Ambient Air Quality Objectives/Guidelines, where applicable.

3. To determine geographic areas where elevated levels might occur

The following sections summarize applicable air quality objectives, sampling and monitoring procedures used, results, and a discussion of data obtained.

2. MANITOBA AIR QUALITY OBJECTIVES AND GUIDELINES

Manitoba Air Quality Objectives and Guidelines have been formulated for various air pollutants. The limits for sulphur dioxide and suspended particulate have been adopted from the National Air Quality Objectives, while allowable levels for sulphuric acid mist are currently proposed guidelines. (See Table 1).

The provincial criteria have been established for two levels:

Maximum Acceptable Level (MAL) - This level is intended to provide adequate protection against effects on soil, water, vegetation materials, animals visibility, personal comfort and well being.

Maximum Desirable Level (MDL) - This level defines long term goals for air quality and provides a basis for anti degradation policy for the unpolluted parts of the province for the continuing development of control technology.

2.1 Sulphur Dioxide

Background levels of sulphur dioxide in the atmosphere have been determined as 4 micrograms per cubic metre ($\mu g/m^3$) or less, and no current evidence indicates that these levels can cause harm to the environment [5]. Levels well in excess of background concentrations can, however, have a deleterious effect on vegetation and human health.

The maximum acceptable levels have been determined on the basis of the following considerations:

Levels of less than 900 $\mu g/m^3$ (0.34 ppm) average for one hour will help prevent discomfort to sensitive individuals, with respect to taste and odour, and will prevent the persistence of concentrations of SO_2 for several hours, which has the potential to injure vegetation.

Levels of less than 300 $\mu g/m^3$ (0.11 ppm) averaged over 24 hours will help prevent health effects, while levels of less than 60 $\mu g/m^3$ (0.02 ppm) averaged over one year will minimize chronic effects in forests.

The maximum desirable levels have been justified on the basis of being at or below the threshold of very slight human effects and very slight chronic effects to forests.

2.2 Sulphuric Acid Mist

Sulphuric acid mist in the atmosphere has been determined to have a deleterious effect on ecological systems, damaging vegetation and killing certain animal species[9]. This compound is also found to cause corrosion of metals and leaching of construction materials such as limestone and marble. However, the most important effect of sulphuric acid is in the area of human health, with studies indicating that continued exposure causes increased resistance to pulmonary flow and suppressed central nervous system response.

Proposed guidelines for a maximum acceptable ambient level for sulphuric acid mist are set at 100 $\mu g/m^3$ based upon a one hour time weighted average.

2.3 Total Suspended Particulate

Particulate matter is one of the most commonly perceived forms of pollution, often manifesting itself by interference with visibility, a soiling effect on materials, or as a respiratory irritant.

The maximum acceptable levels [5] have been designed to prevent undue visibility reduction (visibility reduced to below 8 kilometers when particulate exceeds 100 $\mu g/m^3$) and to minimize respiratory effects.

The maximum desirable levels have been justified on the basis of being similar to background values and at the range where a social awareness of particulate pollution arises.

TABLE 1 - AMBIENT AIR QUALITY CRITERIA

CONTAMINANT	AVERAGING PERIOD	MAX. DESIRABLE LEVEL	MAX. ACCEPTABLE LEVEL
Sulphur Dioxide	1-hour	450 (0.17)	900 (0.34)
	24-hour	150 (0.06)	300 (0.11)
	Annual	30 (0.01)	60 (0.02)
Sulphuric Acid Mist	1 hour		100*
Total Suspended Particulate	24-hour		120
	Annual	60	70

Concentrations are expressed in units of micrograms of contaminant per cubic meter ($\mu g/m^3$) of air corrected to standard conditions of 25°C and 101.3 kilopascals of pressure. The part per million - ppm - (by volume) equivalent concentrations are given in parentheses.

* Proposed Limit

3. PROCEDURES

3.1 Sulphur Dioxide (SO_2)

Monitoring for sulphur dioxide was performed using a Thermo Electron Model 43 pulsed fluorescence ambient SO_2 analyzer. Pulsating ultraviolet light is focused through a narrow bandpass filter into a fluorescence chamber. Sulpur dioxide molecules are excited to a higher energy state in the chamber then give off a decay radiation (light) characteristic for SO_2. This radiation is allowed to pass selectively through a second filter to impinge on a photomultiplier tube. the light emissions are processed electronically, such that the light energy is converted into a voltage signal which is proportional to the concentration of sulphur dioxide in the sample being analyzed. This method is highly specific, with few interferences.

3.2 Sulphuric Acid Mist

Monitoring was undertaken for sulphuric acid mist, using NIOSH method P&CAM 187[7]. A sequential sampling system was used to draw ambient air through an impinger system containing distilled water at a rate of 1.5 L/min over a period of one hour. Samples collected were submitted to the W. H. Ward Technical Services Laboratory for analysis of total sulphate concentration. This parameter has been used in a number of jurisdictions [12, 13, 14] for establishment of ambient sulphuric acid concentrations.

3.3 Total Suspended Particulate

Sampling for total suspended particulate (TSP) was performed in accordance with the Environment Canada reference method, "Standard Reference Method for the Measurement of suspended Particulate in the Atmosphere (High Volume Method)", EPS Report No. 1-AP-73-2 (January 1973).

In summary, the procedure consists of drawing air through a glass fibre filter paper (Gelman type A/E) at an average flowrate of between 1.13 and 1.70 cubic metres per minute. This filter, 406 cm^2 in area (approximately 20 x 25.5 cm) located on the intake side of the pump, entraps particulate in a size range of 0.3 µm in diameter (at a 99% efficiency rate) up to 100 µm in diameter. Pre-weighed filters are weighed after exposure to determine the mass of particulate collected. The concentration in air (of TSP) is calculated by dividing the mass by the total volume of air sampled. Total air volume is recorded on a flow transducer chart.

Preparation and analysis of filters was carried out at the W. M. Ward Technical Services Laboratory using prescribed methodology.

3.4 Wind Speed and Direction

Wind speed and direction were obtained from an on-board meteorological tower. The tower with a Windflo 540 wind speed and direction sensing instrument, manufactured by the Athabasca Research Corporation Ltd., was raised to a 10 metre height. Wind speeds were recorded on strip charts during the monitoring program. The output from the anemometer is a voltage, and was converted to appropriate engineering units (i.e. km/hr). The same principle applied to the wind direction. Directions are given relative to true north taking into account the magnetic declination of approximately 5° east in the vicinity of Lockport.

4. MONITORING SITES

Monitoring was conducted at three sites during the course of the survey. All locations were 0.5 km or less from the Red River Brick and Tile plant.

A detailed site description of each location accompanies Map 1[6] in Appendix A.

5. RESULTS

Hourly averaged concentrations for sulphur dioxide and sulphuric acid mist measured at each sampling site are shown in Table 2. Corresponding wind speed and directions measured on site and operator general comments are also included.

Hourly averages were calculated for sulphur dioxide using 12-5 minute average concentrations obtained by visual averaging of the strip chart record. Acid mist concentrations were calculated based upon total sulphate concentrations measured from analyzed samples submitted to the W. M. Ward Technical Services Laboratory.

Table 3 summarizes total suspended particualte levels measured on site for the time duration of sampling.

A summary of sampling duration and average concentrations of sulphur dioxide and sulphuric acid mist are shown for each site in Table 4. Survey date is further summarized for comparison of downwind versus background levels in table 5.

TABLE 2. MONITORING RESULTS

RED RIVER BRICK AND TILE STUDY

Time (Hours)	Site No.	SO_2 Conc (ppm) 1 hr TWA	H_2SO_4 ($\mu g/m^3$) Conc.	Wind Dir.	Wind km/hr Speed	Comments
May 16						
11:00-12:00	1	.14	328	137	37	
12:00-13:00		.17	297	132	37	
13:00-14:00		.15	47	132	37	
14:00-15:00		.19	344	127	35	
15:00-16:00		.22	328	127	39	
16:00-17:00		.20	328	137	41	
17:00-18:00		.15	63	137	40	
18:00-19:00		.07	141	142	38	
19:00-20:00		.10	141	142	38	
20:00-21:00		.06	391	142	33	
21:00-22:00		.39*	688	132	35	
22:00-23:00		.37*	547	132	39	
23:00-24:00		.23	234	137	39	
May 17						
00:00- 1:00		.11	78	137	39	
1:00- 2:00		<.01	<30	152	41	
2:00- 3:00		<.01	<30	153	37	
3:00- 4:00		<.01	<30	163	40	
4:00- 5:00		<.01	<30	175	35	
5:00- 6:00		<.01	-	185	27	
6:00- 7:00		<.01	-	206	31	
7:00- 8:00		<.01	-	194	31	
8:00- 9:00		<.01	-	194	35	
9:00-10:00		<.01	-	220	38	
10:00-11:00		<.01	-	220	41	
11:00-12:00		<.01	-	220	39	

* Level Exceeds Guideline Values

TABLE 2. - (Continued)

Time (Hours)	Site No.	SO_2 Conc (ppm) 1 hr TWA	H_2SO_4 ($\mu g/m^3$) Conc.	Wind Dir.	Wind km/hr Speed	Comments
May 29						
11:00-12:00	2	.23	438	170°	23	
12:00-13:00		.18	234	164°	23	
13:00-14:00		.09	109	170°	25	
14:00-15:00		.12	296	170°	23	
15:00-16:00		.21	281	155°	23	
16:00-17:00		.22	312	155°	27	
17:00-18:00		.30	687	155°	29	
18:00-19:00		.36*	625	155°	30	
19:00-20:00		.34*	640	155°	27	
20:00-21:00		.17	422	155°	28	
21:00-22:00		.18	531	155°	25	
22:00-23:00		.18	<30	155°	27	
23:00-24:00		.37	859	159°	27	
May 30						
00:00- 1:00		.25	281	159°	21	
1:00- 2:00		<.01	78	169°	25	
2:00- 3:00		<.01	78	180°	27	
3:00- 4;))		<.01	78	180°	25	
4:00- 5:00		<.01	78	180°	21	
5:00- 6:00		.02	78	180°	17	
6:00- 7:00		.02	141	180°	21	
7:00- 8:00		<.01	187	175°	25	
8:00- 9:00		<.01	125	180°	27	
9:00-10:00	3	.06	156	180°	27	
10:00-11:00		.40*	718	160°	34	
11:00-12:00		.30	125	175°	38	

*Level Exceeds Guideline Values.

TABLE 2. - (Continued)

Time (Hours)	Site No.	SO_2 Conc (ppm) 1 hr TWA	H_2SO_4 ($\mu g/m^3$) Conc.	Wind Dir.	Wind km/hr Speed	Comments
12:00-13:00	3	.27	63	185°	38	
13:00-14:00		.25	94	185°	39	
14:00-15:00		.23	141	185°	34	
15:00-16:00		.14	469	196°	33	
16:00-17:00		.03	187	201°	31	
17:00-18:00		.03	140	201°	30	
18:00-19:00		.24	625	185°	25	
19:00-20:00		.03	47	79°	15	
20:00-21:00		.07	47	116°	8	
21:00-22:00		<.01	140	148°	9	
22:00-23:00		<.01	78	95°	10	
23:00-24:00		.28	N.D.	162°	17	
May 31						
00:00- 1:00		.47*	N.D.	180°	25	
1:00- 2:00		.54*	N.D.	190°	23	
2:00- 3:00		.35*	N.D.	185°	23	
3:00- 4:00	3	.05	N.D.	201°	19	
4:00- 5:00		.06	N.D.	175°	17	
5:00- 6:00		.23	N.D.	175°	15	
6:00- 7:00		.06	N.D.	175°	17	
7:00- 8:00		.09	N.D.	159°	15	
8:00- 9:00		.17	N.D.	159°	15	
9:00-10:00		.21	N.D.	190°	19	
10:00-11:00		.25	N.D.	175°	21	
11:00-12:00		.17	78	180°	23	
12:00-13:00		.09	94	170°	27	
13:00-14:00		.03	219	159°	28	

*Level Exceeds Guideline Values.

N.D. No Data

TABLE 2. - (Continued)

Time (Hours)	Site No.	SO_2 Conc (ppm) 1 hr TWA	H_2SO_4 ($\mu g/m^3$) Conc.	Wind Dir.	Wind km/hr Speed	Comments
14:00-15:00	3	.06	230	164°	28	
15:00-16:00		.13	94	170°	27	
16:00-17:00		.08	78	170°	27	
17:00-18:00		<.01	<30	143°	25	
18:00-10:00		.16	N.D.	159°	25	
19:00-20:00		<.01	<30	296°	21	
20:00-21:00		<.01	<30	301°	N.D.	
21:00-22:00		<.01	<30	312°	N.D.	
22:00-23:00		<.01	<30	305°	N.D.	
23:00-24:00		<.01	<30	305°	N.D.	
June 1						
00:00- 1:00		<.01	<30	305°	N.D.	
1:00- 2:00		<.01	<30	296°	N.D.	
2:00- 3:00		<.01	<30	285°	N.D.	
3:00- 4:00		<.01	<30	255°	N.D.	
4:00- 5:00		<.01	<30	285°	N.D.	
5:00- 6:00	3	<.01	<30	296°	N.D.	
6:00- 7:00		<.01	<30	285°	N.D.	
7:00- 8:00		<.01	<30	301°	N.D.	
8:00- 9:00		<.01	<30	306°	N.D.	
9:00-10:00		<.01	<30	318°	N.D.	

*Level Exceeds Guideline Value

N.D. - No Data

TABLE 3. SUSPENDED PARTICULATE LEVELS IN THE VICINITY OF RED RIVER BRICK AND TILE

Date	Site No.	Particulate Conc. ($\mu g/m^3$)
May 16 - 17	1	234
May 29 - 30	2	138
May 30 - 31	3	194
May 31 - June 1	3	242

TABLE 4 - SURVEY DATA SUMMARY (a)

Site No.	Times and Date	No. of Hours	Average Conc. SO_2 (ppm)	Average Conc. H_2SO_4 ($\mu g/m^3$)
1	11:00 16/5/84-12:00 17/5/84	25	0.11	
		18		220
2	11:00 29/5/84- 9:00 30/5/84	23	0.14	285
3	9:00 30/5/84-10:00 1/6/84	49	0.12	
		37		103

TABLE 5 - SURVEY DATA SUMMARY (b)

	SO_2	H_2SO_4
Total No. of Monitoring Hours	97	78
Downwind Monitoring (hrs)	60	48
% of Total	61.8%	61.5%
Average Concentration	0.188 ppm	226 $\mu g/m^3$
Background (not downwind) Monitoring	37	30
% of Total	38.2%	38.5%
Average Concentration	<0.01 ppm	<30 $\mu g/m^3$
Total 1 Hr. Exceedances (MAQO)	9	38
Downwind Exceedances	9	38
% of Total	100	100

DISCUSSION

Monitoring for this study was performed in two segments, May 16-17 and May 29-June 1, 1984. The first survey (starting May 16) was characterized by strong winds (30-40 km/hr) throughout the monitoring period, with overcast conditions and cool temperatures. Weather conditions were such that emissions from the kiln exhaust stack were held close to the ground, impinging on downwind areas with regular frequency. Under the described conditions the sulphur dioxide concentration was found to exceed the SO_2 one hour guideline on two occasions (May 16 21:00 h - .39 ppm 22:00 h - .37 ppm). Eleven exceedances of the proposed limit for sulphuric acid mist were recorded during the first survey, based upon a one hour average, when the MMU was in a downwind venue from the plant.

During the second survey, various meteorological conditions were observed. Brisk to strong winds were present throughout, with clear conditions on May 29 and 30, overcase on May 31, and clear conditions again on June 1. Temperatures were moderate during the entire second survey. Seven exceedances of the SO_2 1 hour guideline were recorded during the second survey (May 29 19:00 h - 0.36 ppm, 19:00 h - .34 ppm, 23:00 h - .37 ppm May 30 10:00 h - .40 ppm, May 31 24:00 h - .47 ppm, 1:00 h - .54 ppm 2:00 h - .35 ppm). Twenty-seven exceedances of the proposed standard for sulphuric acid mist were monitored during the second survey, when the MMU was downwind of the plant.

It should be noted that the sulphuric acid data is of a preliminary nature. Very few methods currently exist for measurement of acid mist as a specific parameter, due to the difficulty of separating the sulphuric acid aerosol component from other possible interferents in the sample. Chemical measurement of this parameter involves analysis for one of the reactive species in the molecule (i.e. hydrogen ion or sulphate ion). Current recommended analytical methods involve measurements of total sulphate (SO_4^{-2}) in the sample, as hydrolysis of other soluble acidic and basic constituents in an air sample will mask the hydrogen ion (H^+) contribution from the sulphuric acid mist present.

Sampling for suspended particulate levels was undertaken for four days during this study. All four samples taken were found to exceed the Maximum Acceptable Level of 120 $\mu g/m^3$ based upon a 24 hour average. One major emission source for particulate was observed to be the clay stock piles on the plant property. Dust from these piles is entrained by the wind and deposited on neighbouring roads and land. However, the levels of total suspended particulate in the area may have a significant background component (soil from fields and dust from other sources), such that it is difficult to quantify what portion of the particulate is emitted directly from the plant operation.

A downwind location from the plant was determined by comparison of wind direction and the compass bearing of the plant with respect to the monitoring site. This bearing, plus or minus 20°, yields the direction range within which the receptor site is considered to be downwind of the source. This is only a generalization, however, and other factors, such as the distance from source to receptor, wind velocity and variability of the horizontal wind component will influence this range. For this study, the following ranges were used:

i) Site #1 is downwind of the Red River Brick and Tile plant when the wind direction (hourly average) ranged between 105° and 145° (i.e. 125° $\pm$ 20°).

ii) Site #2 is downwind of the RRBT plant when the wind direction ranged between 130° and 170°.

iii) Site #3 is downwind of the RRBT plant when the wind direction ranged between 160° and 200 °.

A comparison of the Manitoba Air Quality Objectives and Guidelines with conditions monitored downwind for the two averaging time period is as follows:

One-hour

(1) Number of cardinal hours (downwind) when the 1 hour Maximum Acceptable Level (MAL) was exceeded for sulphur dioxide was 9 out of 60 (15%).

(2) Number of cardinal hours (downwind) when the one hour poposed MAL standard for sulphuric acid mist was exceeded was 38 out 48 (79%).

24 Hour

(1) Out of four consecutive 24 hour periods (one from the first survey; three from the second), the number of periods when the hour Maximun Acceptable Level for sulphur dioxide was exceeded was 4 out of 4 (100%).

CONCLUSIONS

Regarding the air quality measurements conducted during this study, it can be concluded that:

(1) Under meteorological conditions similar to those experienced during this study, Manitoba Air Quality Guidelines for sulphur dioxide based upon 1 hour and 24 hour periods could be exceeded.

(2) Under the conditions described previously, Manitoba Air Quality Guidelines for suspended particulate could be exceeded during a 24 hour period.

(3) Downwind concentrations of sulphuric acid mist could exceed proposed guidelines, based upon a one hour average.

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(14) State of Pennsylvania. S.A.C. Title 25, Part 1, Subpart C, Article III - Chapter 139.

(15) Map for this study obtained from: Federal Department of Energy, Mines and Resources, Map 62 I/2 Edition 3.

APPENDICES

APPENDIX A

Ambient Air Monitoring Sites

Site No. 1 - Map Grid Reference 493496 (Universl Transverse Mercator Grid UTMG).

Description (a) Spur of Old Highway #44 route.

(b) West-northwest of Red River Brick and Tile Plant (bearing 125° w.r.t. Site #1).

(c) Approximately 300 metres west of RRBT entry road.

(d) Approximately 500 meters from RRBT plant.

Site No. 2 - Map Grid Reference 494496 (UTMG)

Description (a) Spur of old Highway #44 route.

(b) Northwest of RRBT plant (bearing 150° w.r.t. Site #2).

(c) Approximately 200 metres west of RRBT entry road

(d) Approximately 300 metres from RRBT plant.

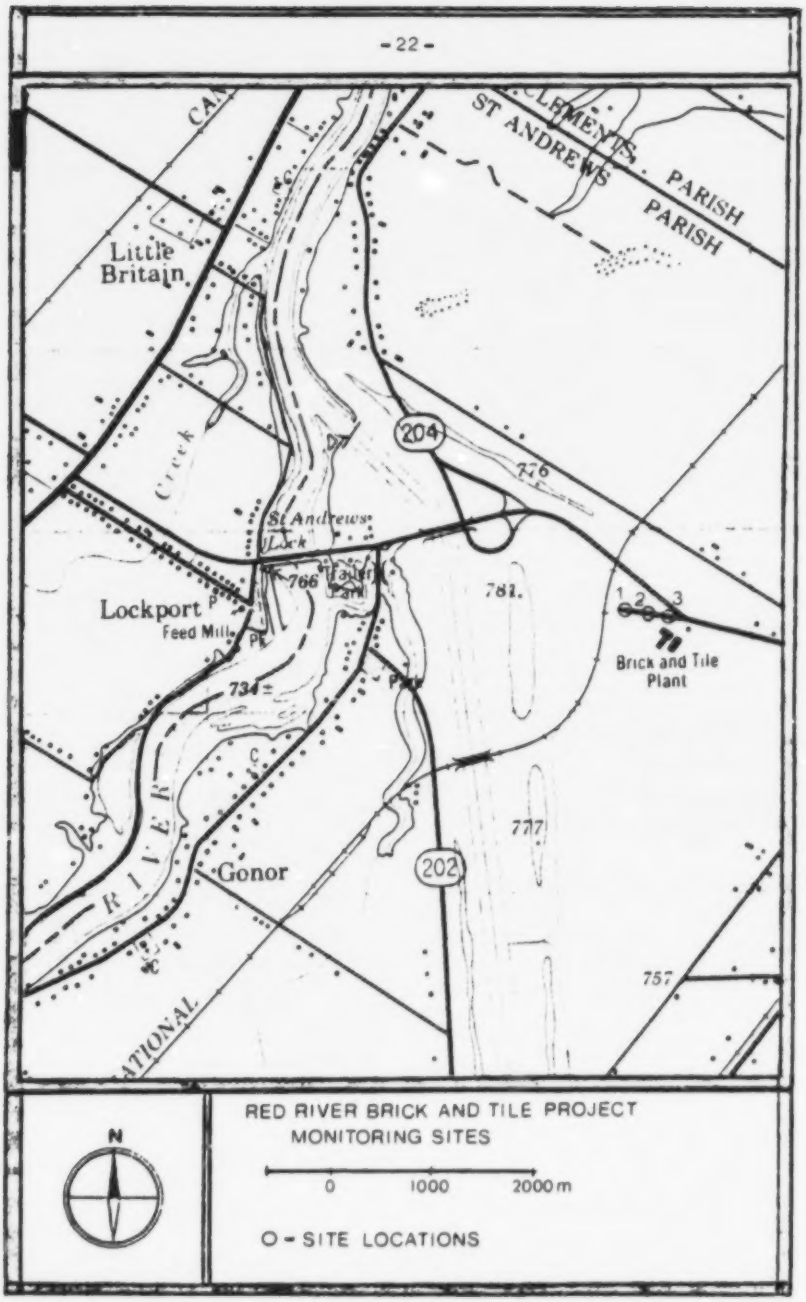
Site No. 3 - Map Grid Reference 49 (UTMG)

Description (a) Spur of old Highway #44 route.

(b) North of RRBT plant (bearing 180° w.r.t. Site #3).

(c) Approximately 50 metres west of RRBT entry road

(d) Approximately 100 metres from RRBT plant.


ST ANDREWS PARISH
ST CLEMENTS PARISH
Little Britain
204
St Andrews Lock
766
Lockport
Feed Mill
734
781
1 2 3
70
Brick and Tile Plant
RIVER
Gonor
202
777
757
N
RED RIVER BRICK AND TILE PROJECT
MONITORING SITES
0 1000 2000 m
O - SITE LOCATIONS